

FIG.1

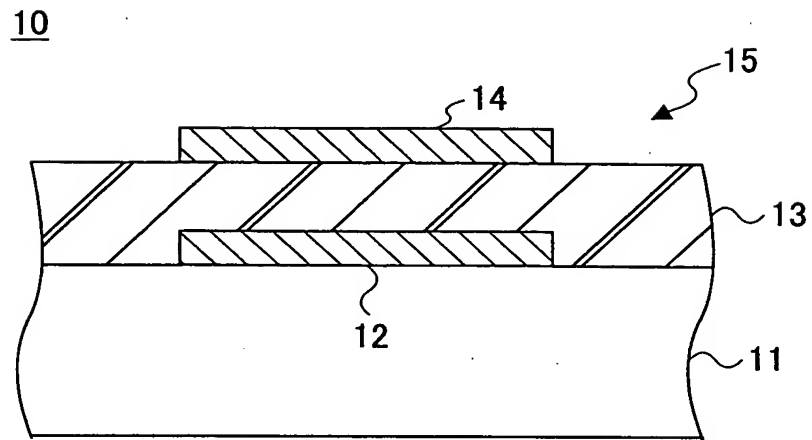


FIG.2

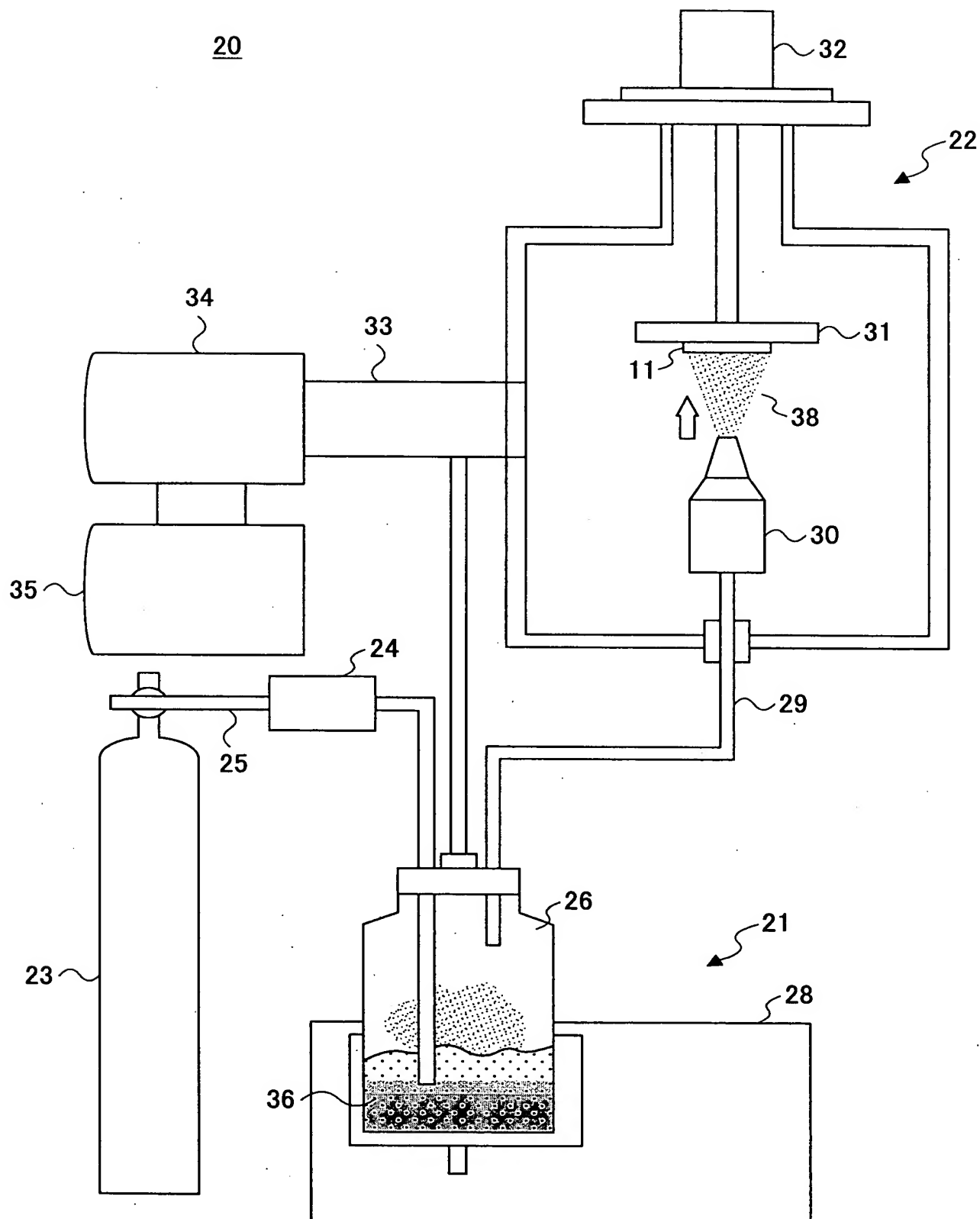


FIG.3

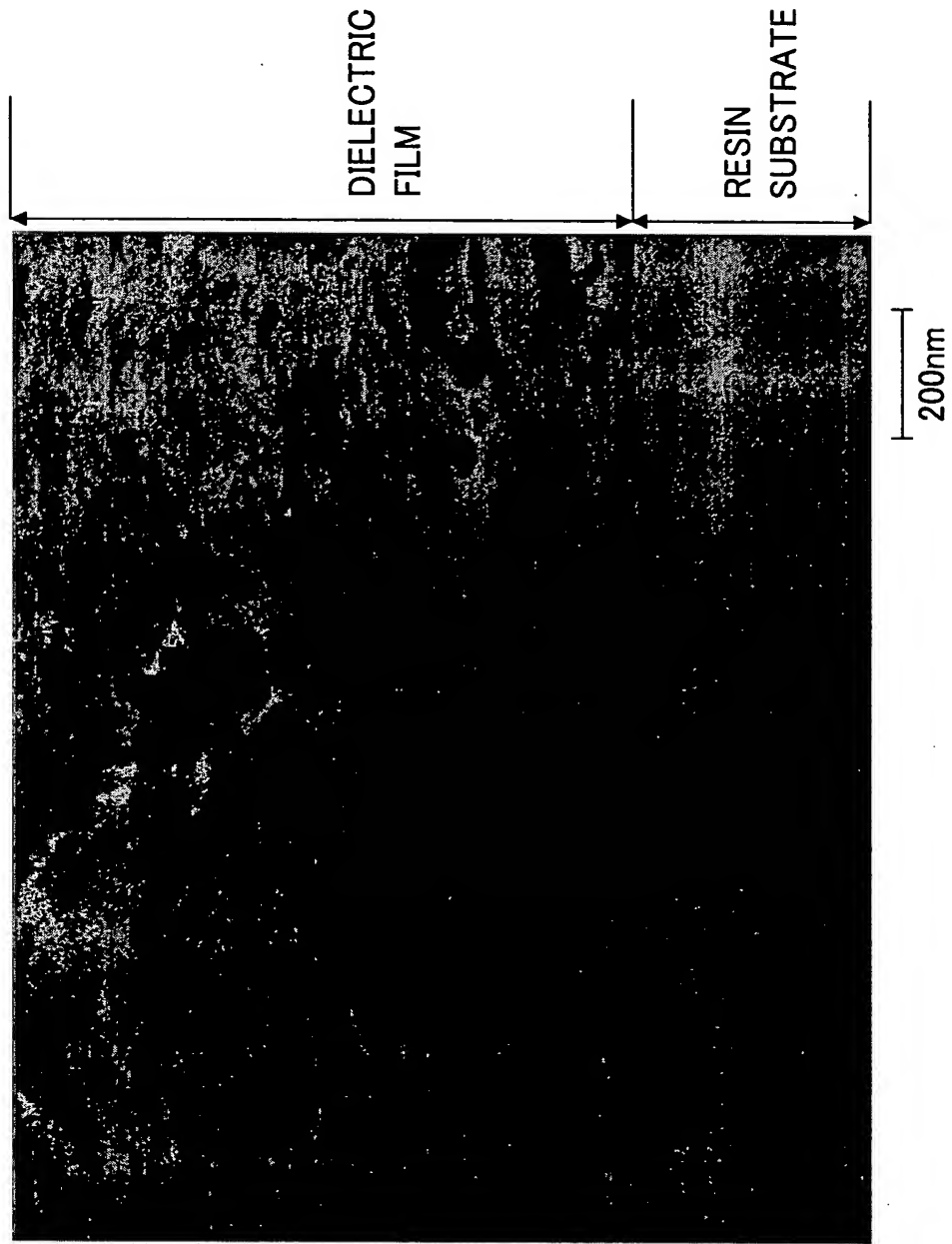


FIG.4

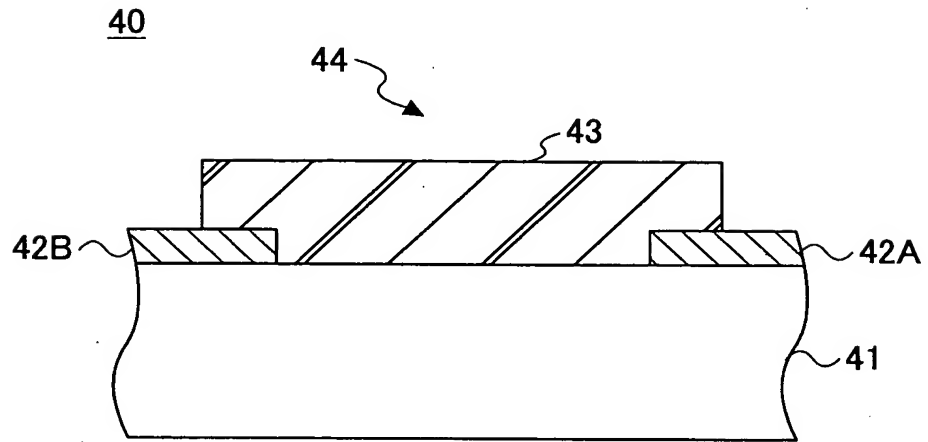


FIG.5

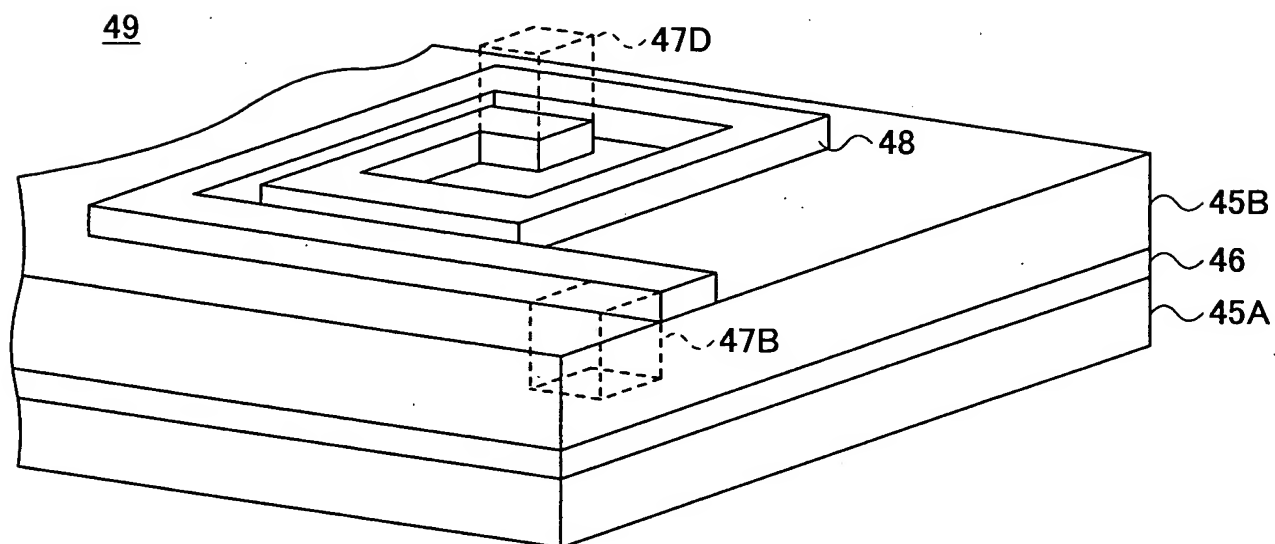


FIG.6

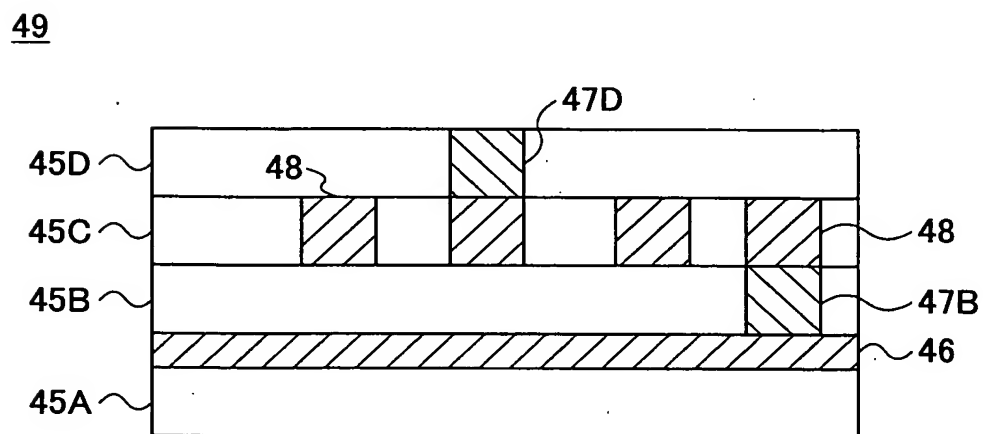


FIG. 7

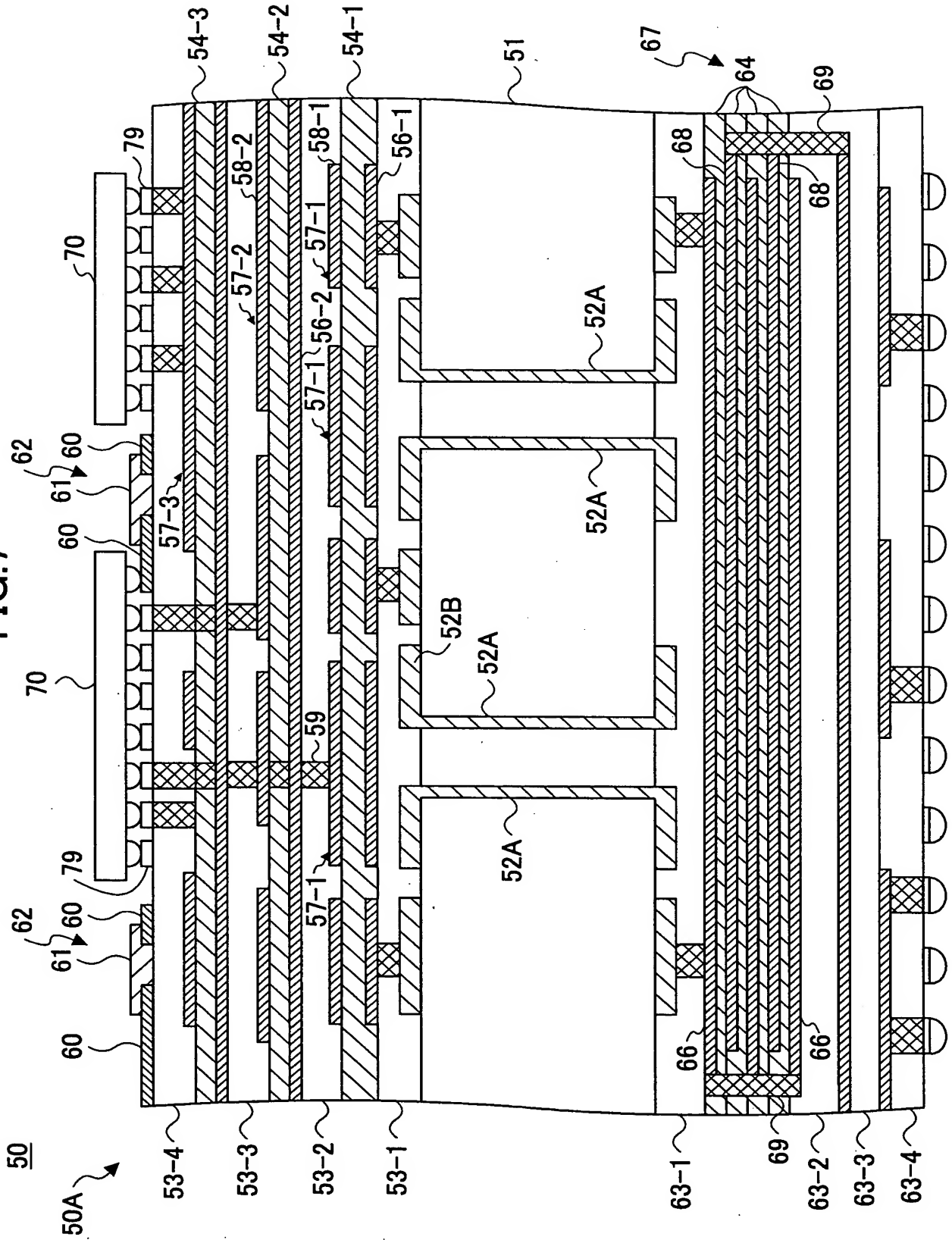


FIG. 8A

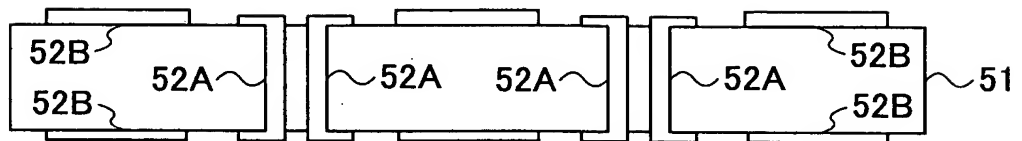


FIG. 8B

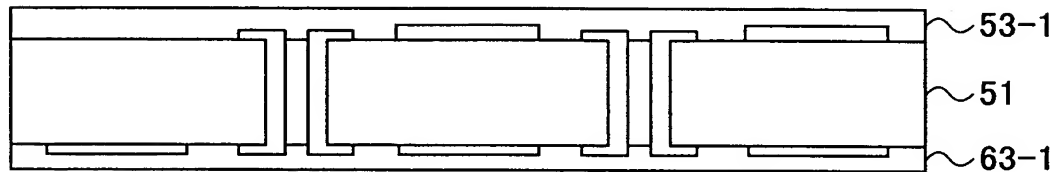


FIG. 8C

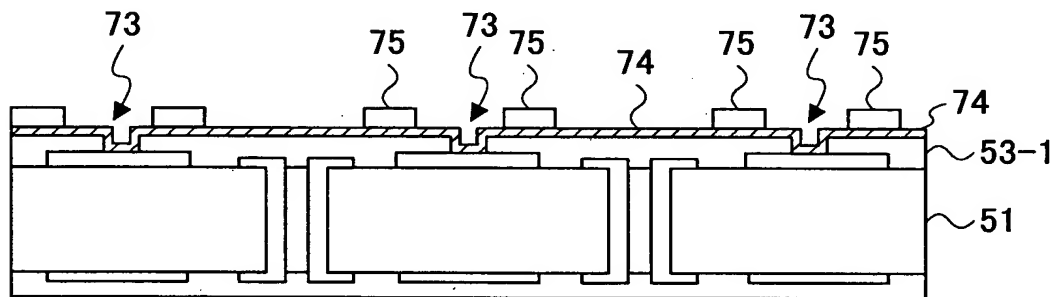


FIG. 8D

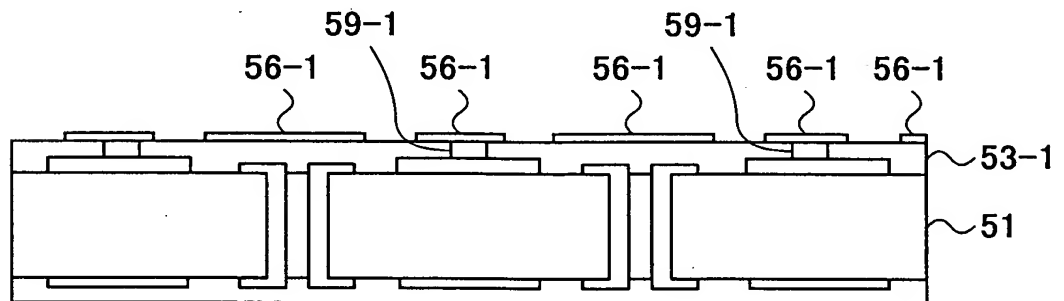


FIG.8E

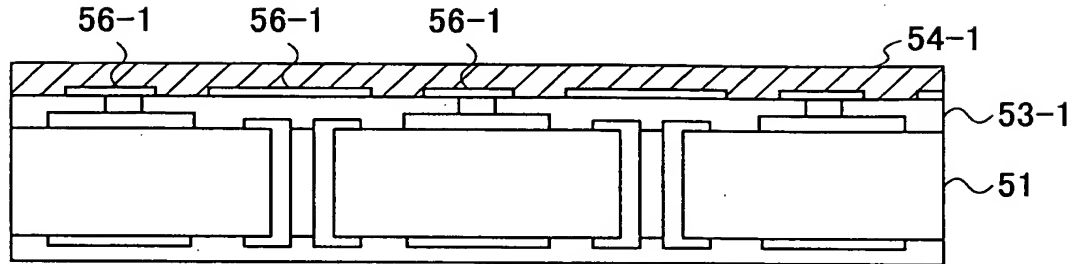


FIG.8F

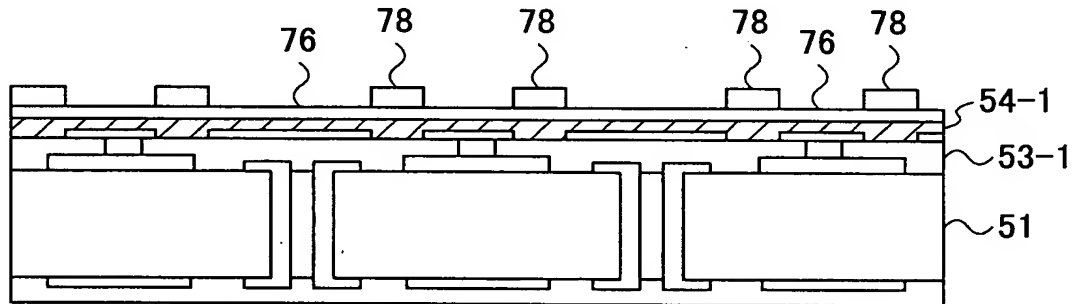


FIG.8G

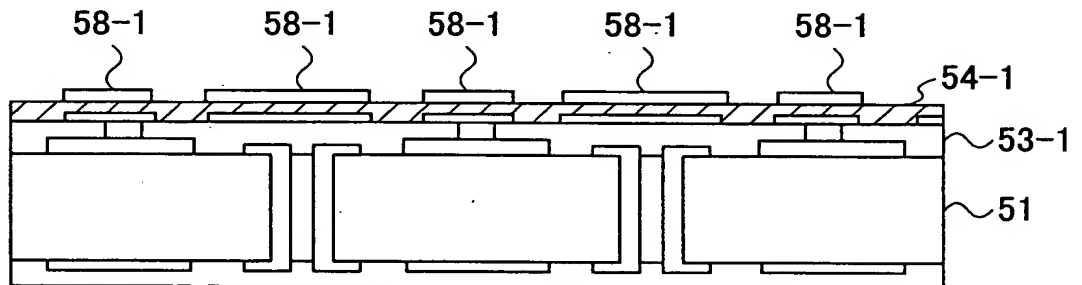


FIG.8H

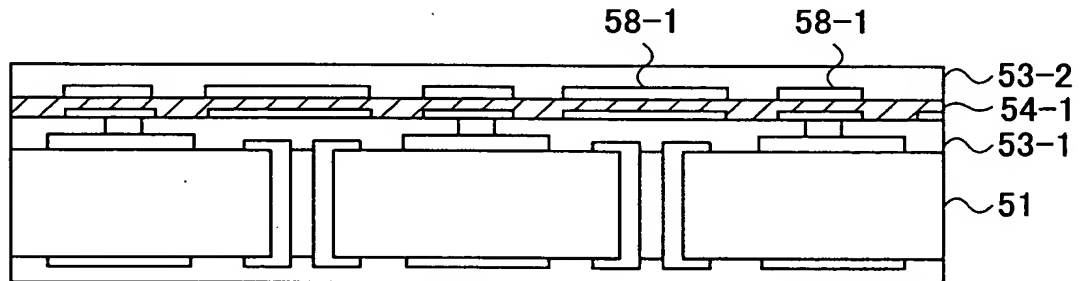




FIG. 9

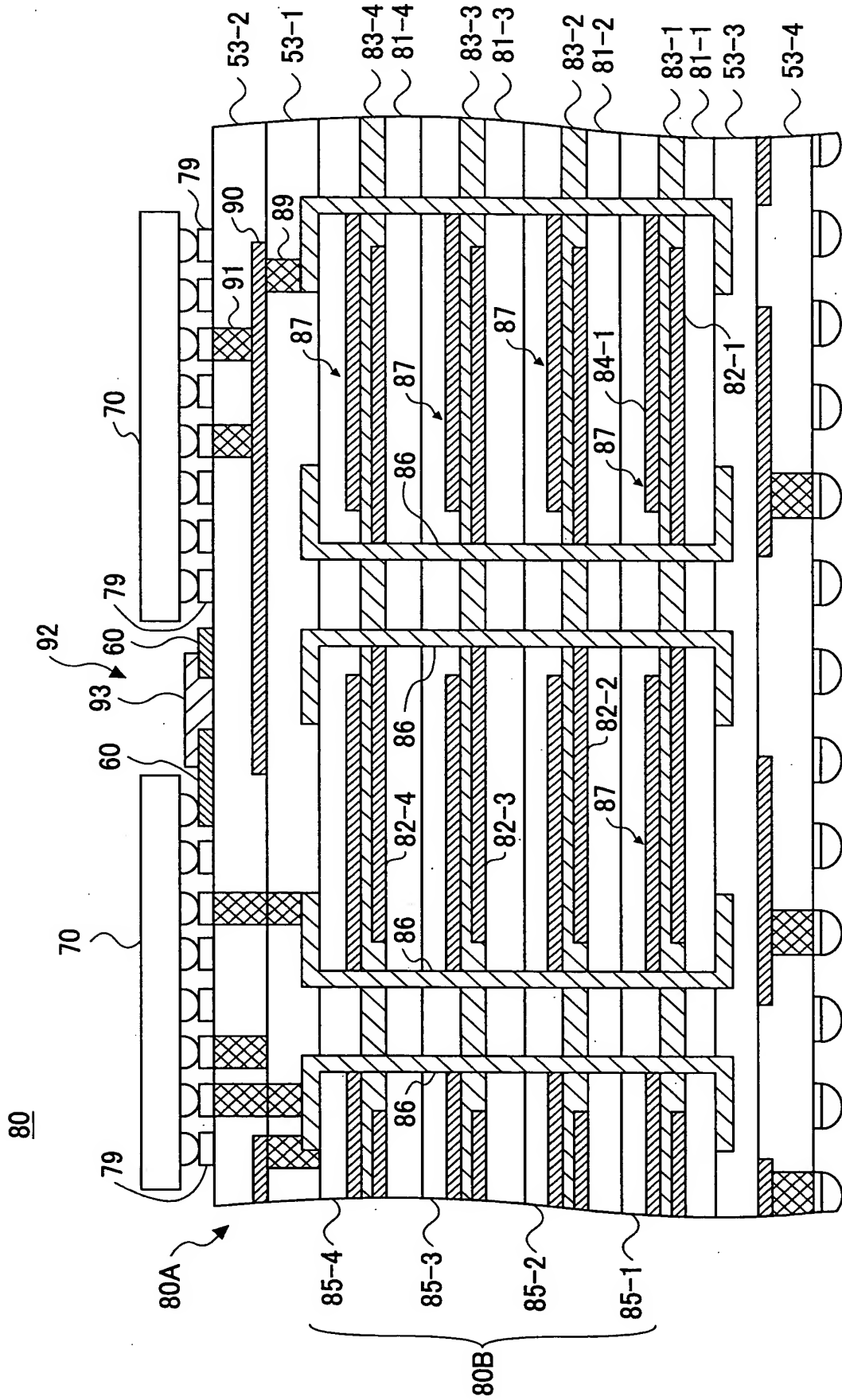


FIG.10

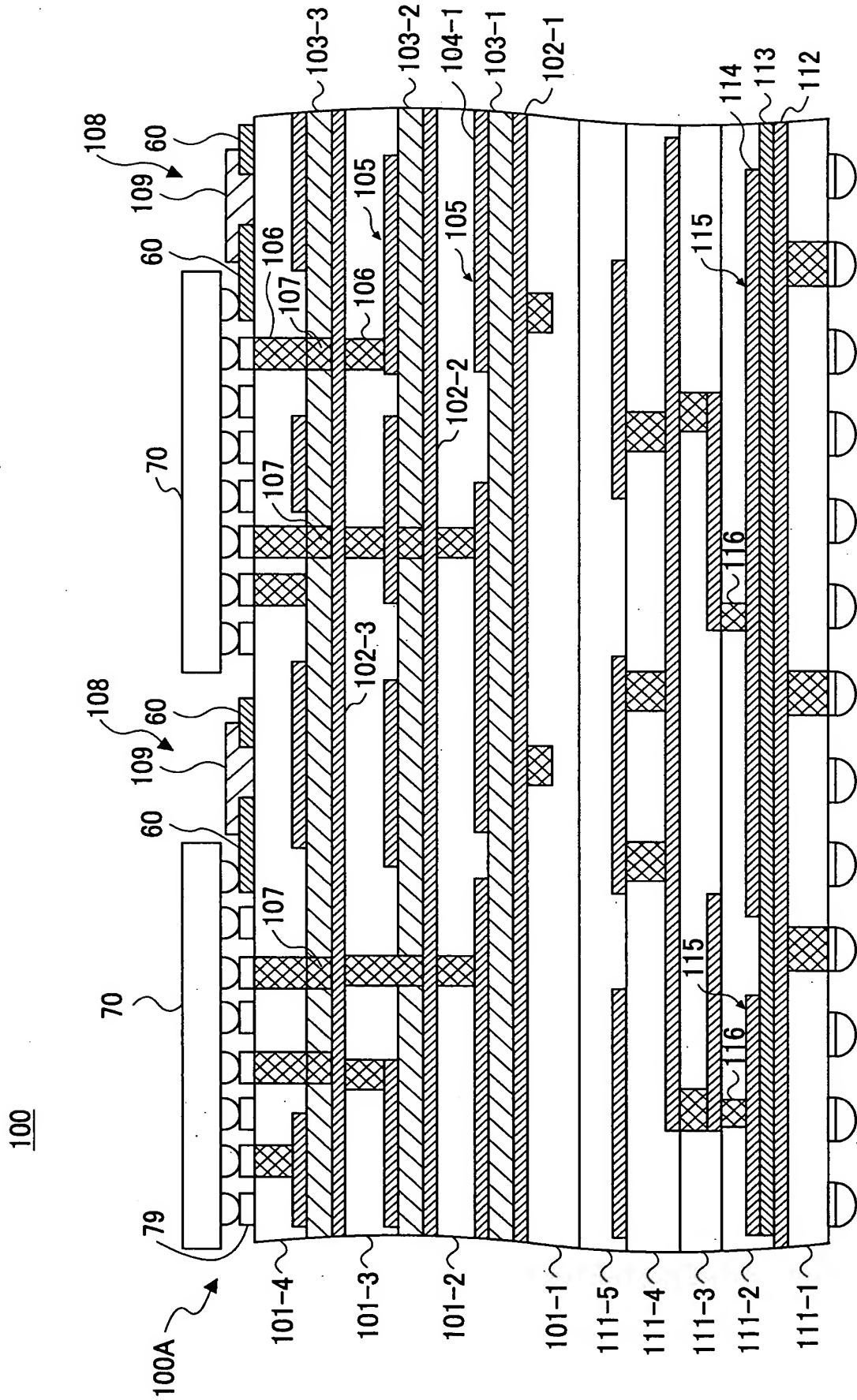


FIG.11A

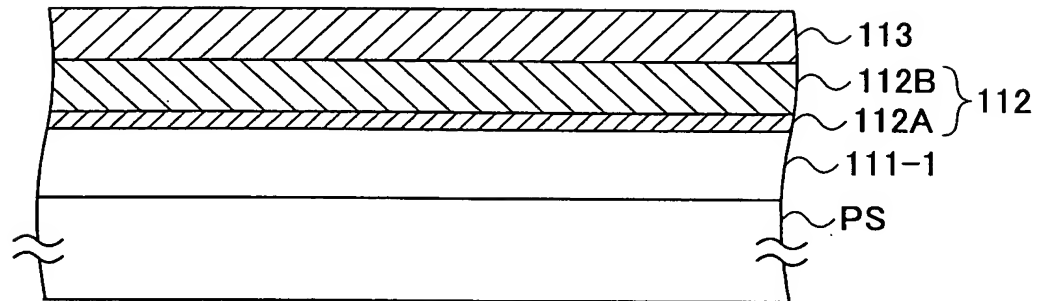


FIG.11B

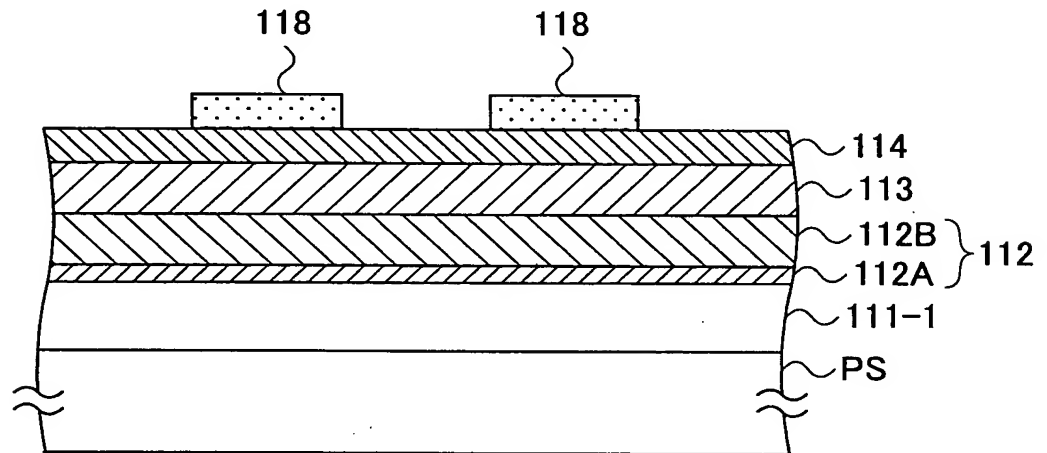


FIG.11C

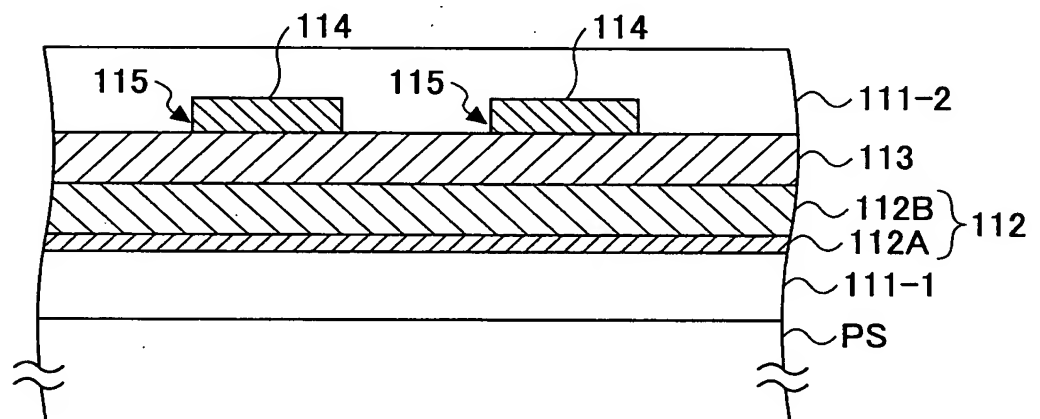
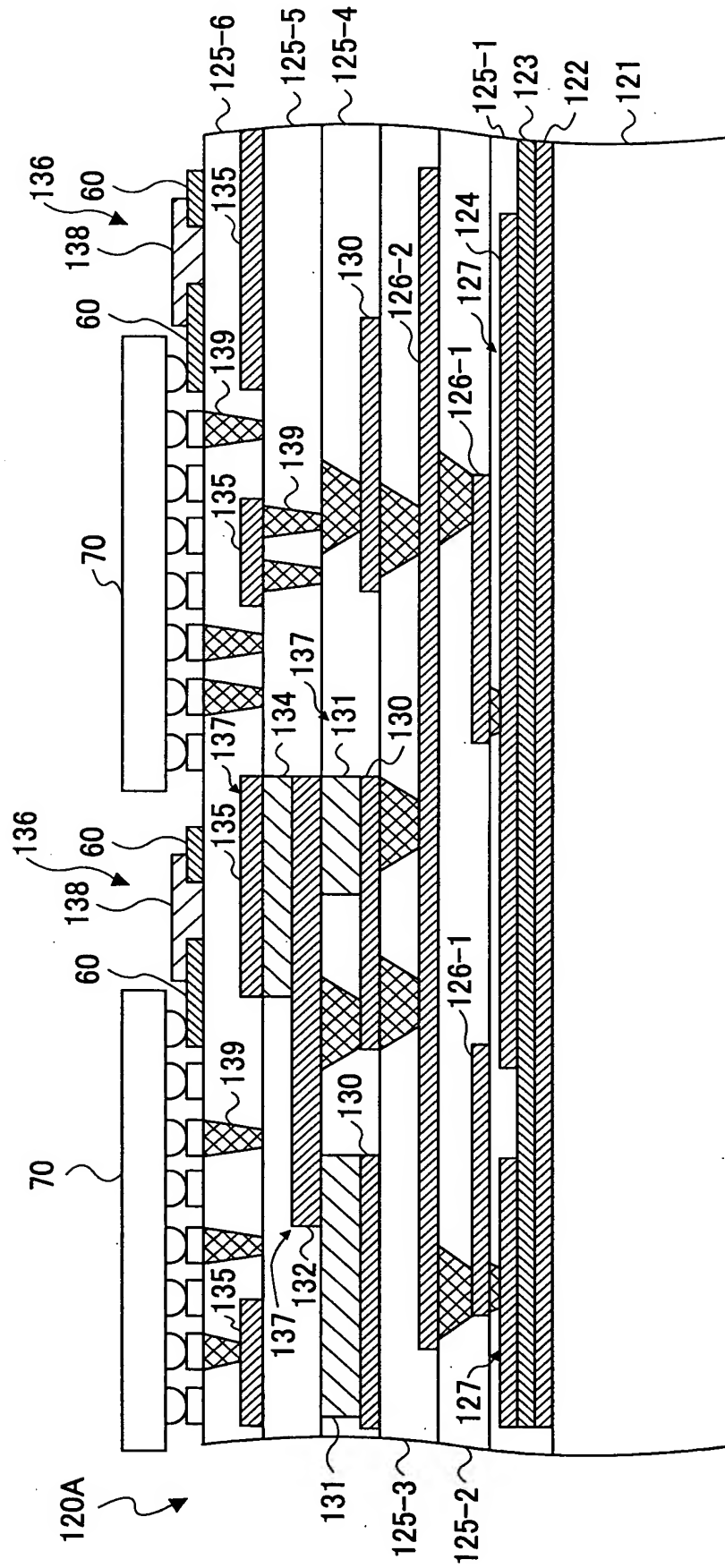


FIG.12

120



**FIG.13**

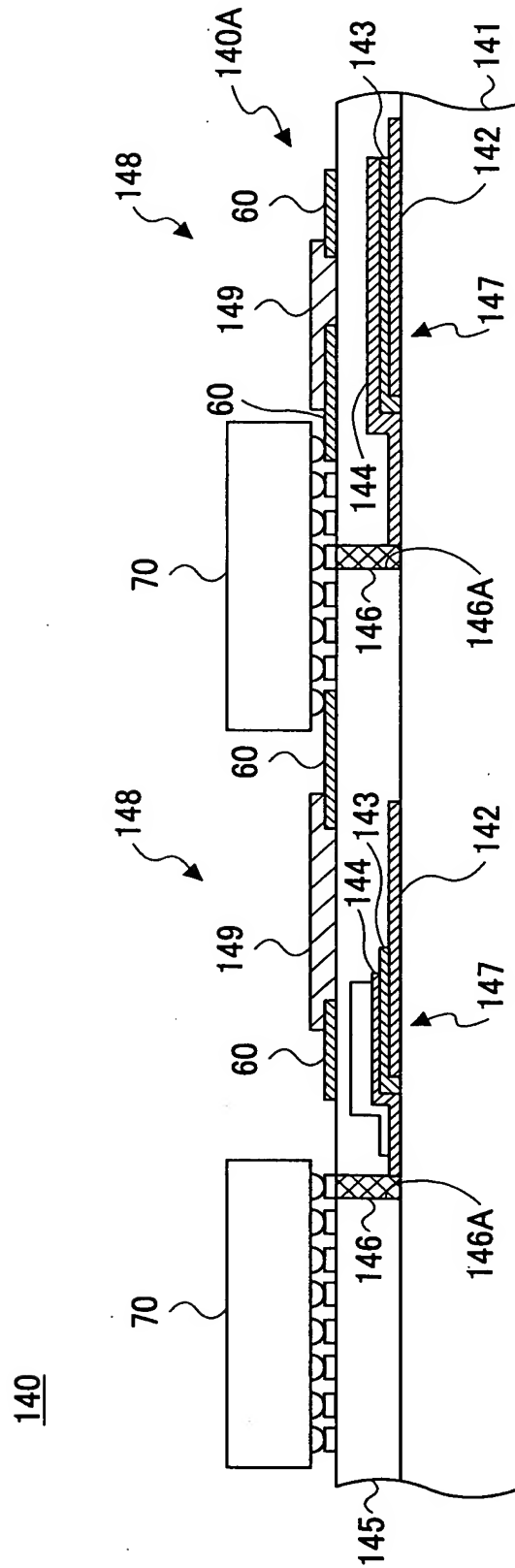


FIG.14

150

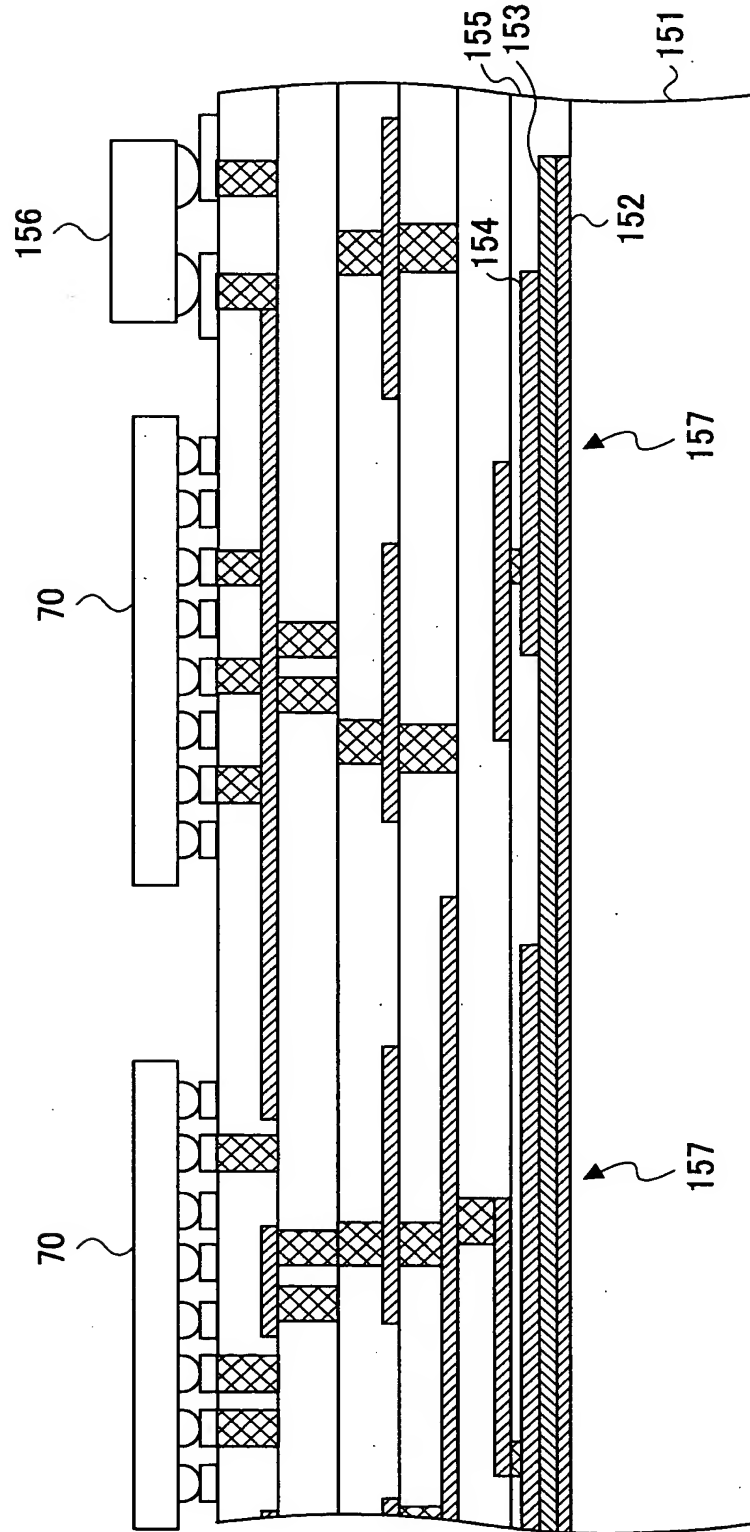


FIG.15

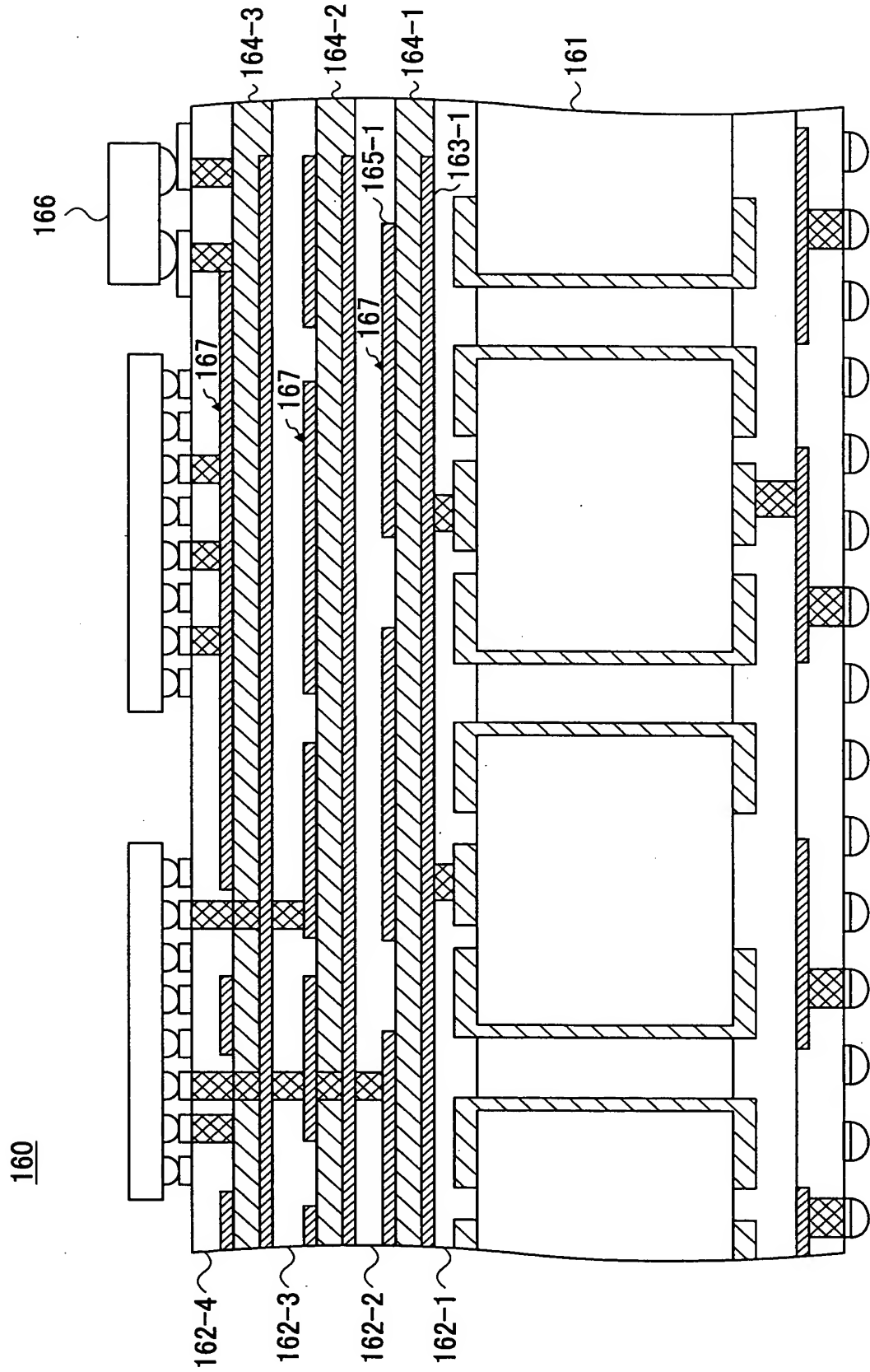


FIG.16

EXAMPLE	SUBSTRATE	INSULATOR	DIELECTRIC FINE PARTICLE	ALUMINA COAT	Ave. DIAMETER ( $\mu$ m)	THICKNESS ( $\mu$ m)	K (1GHz)	CAP. DENSITY (nF/cm <sup>2</sup> )
1	FR-4	EPOXY	TiO <sub>2</sub>	YES	0.3	10	100	80
2	FR-4	EPOXY	BaTiO <sub>3</sub>	YES	0.1	10	1500	1300
3	FR-4	EPOXY	Al <sub>2</sub> O <sub>3</sub>	NO	0.2	10	10	24
4	FR-4	EPOXY	TiO <sub>2</sub>	NO	0.3	10	80	65
5	FR-4	EPOXY	BaTiO <sub>3</sub>	YES	0.3	10	1500	2600
6	POLYIMIDE	POLYIMIDE	BaSrTiO <sub>3</sub>	YES	0.1	10	2000	1800
7	POLYIMIDE	POLYIMIDE	Ba <sub>2</sub> Ti <sub>9</sub> O <sub>20</sub>	YES	0.3	10	20	35
8	Si	POLYIMIDE	Ba <sub>2</sub> Ti <sub>4</sub> O <sub>9</sub>	YES	0.1	10	25	40
9	Si	POLYIMIDE	BaSrTiO <sub>3</sub>	YES	0.1	10	1500	1300
10	Si	POLYIMIDE	BaSrTiO <sub>3</sub> & PbZrTiO <sub>3</sub> MIX	NO	0.1	10	3000	5300
11	RESIN CASE	EPOXY		YES	0.3	10	80	50
COMP1	FR-4	POLYIMIDE	BaSrTiO <sub>3</sub> SPUTTER	—	—	5	10	8
COMP2	FR-4	EPOXY	BaTiO <sub>3</sub> & EPOXY MIX	—	0.1	100	30	0.3



FIG.17

EXAMPLE	RESISTANCE FINE PARTICLE	Ave. DIAMETER ( $\mu$ m)	THICKNESS	$\rho$ ( $\mu \Omega \cdot \text{cm}$ )
1	RuO <sub>2</sub>	0.01	10	16
6	SrRuO <sub>3</sub>	0.01	10	20
8	BiRuO <sub>3</sub>	0.01	10	30
11	Ta <sub>2</sub> O <sub>5</sub>	0.01	10	80
12-1	NiCr	0.01	10	100
12-2	TaN	0.01	10	200
12-3	Ru	0.01	10	10
12-4	Ir	0.01	10	8
12-5	IrO <sub>2</sub>	0.01	10	20

FIG.18

EXAMPLE	PASSIVE COMP ON SUBSTRATE	SUBSTRATE AREA
1	5	0.6
5	4	0.4
6	5	0.5
8	3	0.4
11	10	0.4
COMP1	15	0.8
COMP2	20	1

FIG.19

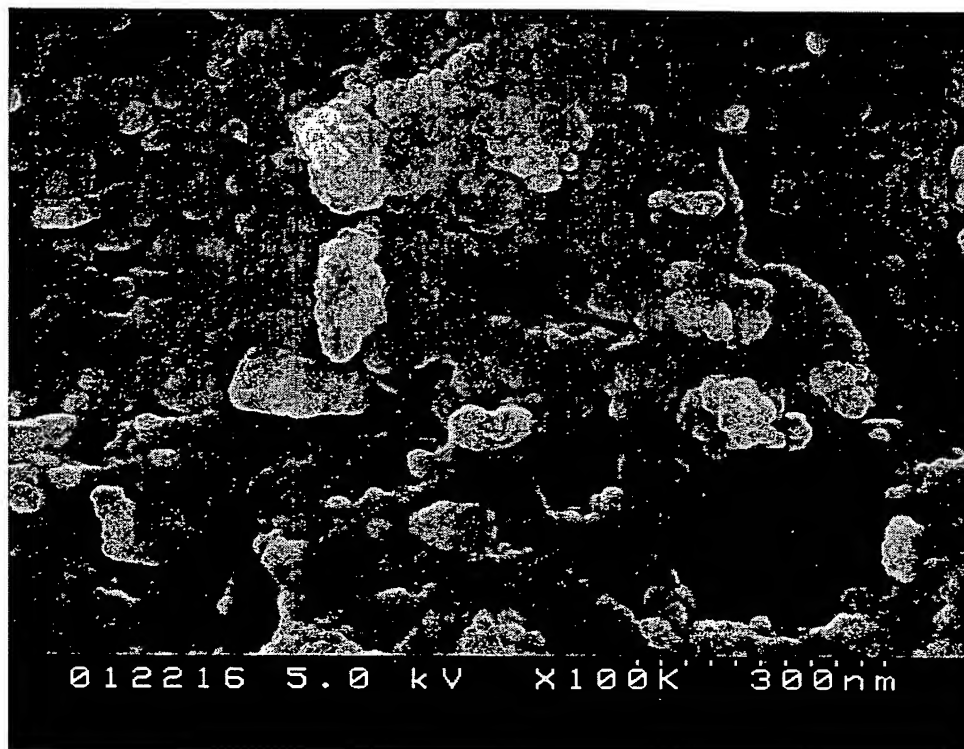


FIG.20

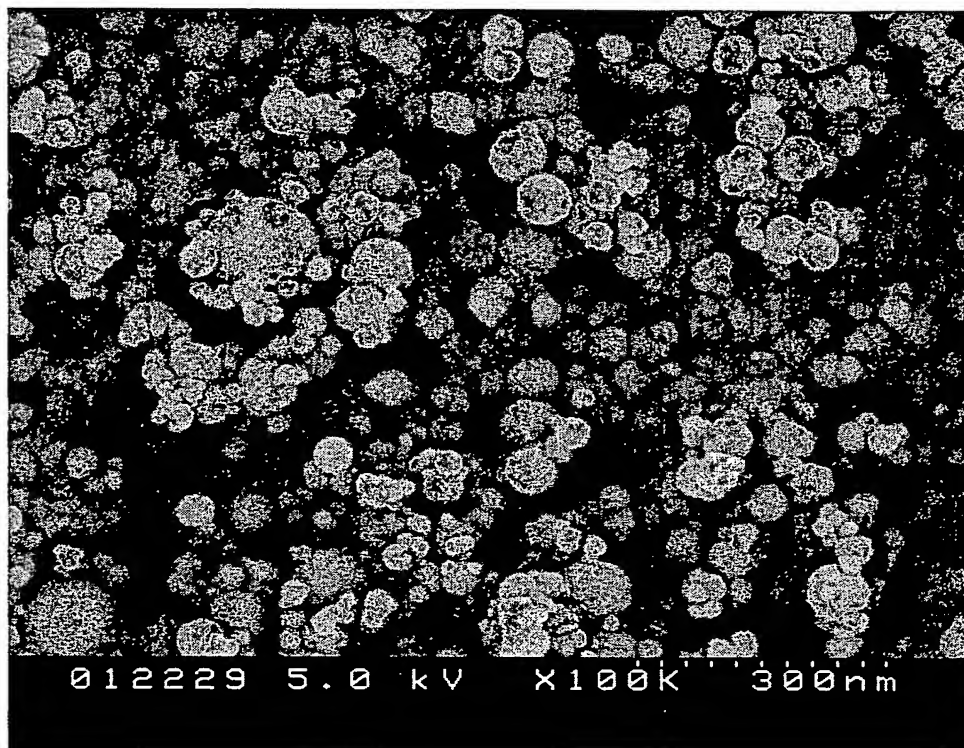


FIG.21

	FINE PARTICLE MATERIAL		MANUFACTURER	PRODUCT NAME	BINDER		THICKNESS ( $\mu$ m)	SUBSTRATE	ADHERENCE (kg/mm <sup>2</sup> )	WATER ABSORPTION (%)
	MATERIAL	Ave. DIAMETER ( $\mu$ m)			COATING (MASS %)	BAKING				
EXAMPLE 13-1	TiO <sub>2</sub>	0.25	TAYCA	JR	5	YES	100	GLASS	$\geq 5.0$	$\leq 0.1$
EXAMPLE 13-2	MgO	0.5	KOJUNDO	—	5	YES	100	GLASS	$\geq 5.0$	$\leq 0.1$
EXAMPLE 13-3	SiO <sub>2</sub>	0.4	KOJUNDO	—	5	YES	100	GLASS	$\geq 5.0$	$\leq 0.1$
EXAMPLE 13-4	AlN	0.5	TOKUYAMA	GRADE F	5	YES	100	GLASS	$\geq 5.0$	$\leq 0.1$
EXAMPLE 13-5	PLZT	0.6	KOJUNDO	—	5	YES	100	GLASS	$\geq 5.0$	$\leq 0.1$
EXAMPLE 13-6	BaTiO <sub>3</sub>	0.20	SAKAI	BT	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-7	RuO <sub>2</sub>	0.05	KOJUNDO	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-8	IrO <sub>2</sub>	0.1	KOJUNDO	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-9	Cu	0.8	KOJUNDO	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-10	W	0.6	KOJUNDO	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-11	Al	0.8	KOJUNDO	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-12	TiC	0.5	KOJUNDO	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-13	TiO <sub>2</sub>	0.10	TAYCA	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-14	TiO <sub>2</sub>	0.05	TAYCA	—	5	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 13-15	TiO <sub>2</sub>	0.25	TAYCA	—	0.10	YES	60	FR-4	$\geq 4.0$	$\leq 0.1$
COMPARATIVE 1	TiO <sub>2</sub>	0.08	TAYCA	—	0.08	YES	30	FR-4	$\leq 1.5$	$\geq 3$
EXAMPLE 13-16	TiO <sub>2</sub>	0.25	TAYCA	—	5	NO	100	GLASS	$\geq 5.0$	$\leq 0.1$
EXAMPLE 13-17	TiO <sub>2</sub>	0.35	TAYCA	JR600A	2	—	100	GLASS	$\geq 5.0$	$\leq 0.1$

FIG.22

	FINE PARTICLE MATERIAL		MANUFACTURER	PRODUCT NAME	THICKNESS ( $\mu$ m)	SUBSTRATE	ADHERENCE (kg/mm <sup>2</sup> )	WATER ABSORPTION (%)
	MATERIAL	Ave. DIAMETER ( $\mu$ m)						
EXAMPLE 14-1	TiO <sub>2</sub>	0.25	TAYCA	JR	40	FR-4	$\geq 4.0$	$\leq 0.1$
EXAMPLE 14-2	Ba(Mg <sub>1/3</sub> Ta <sub>2/3</sub> )TiO <sub>3</sub>	0.20	KOJUNDO	—	60	GLASS	$\geq 4.0$	$\leq 0.1$
EXAMPLE 14-3	RuO <sub>2</sub>	0.05	KOJUNDO	—	5	FR-4	$\geq 4.0$	$\leq 0.1$

FIG.23

	FINE PARTICLE MATERIAL		MANUFACTURER	PRODUCT NAME	BINDER			THICKNESS ( $\mu\text{m}$ )	SUBSTRATE	ADHERENCE ( $\text{kg}/\text{mm}^2$ )	WATER ABSORPTION (%)
	MATERIAL	Ave. DIAMETER ( $\mu\text{m}$ )			MATERIAL	Ave. DIAMETER ( $\mu\text{m}$ )	AMOUNT (MASS%)				
EXAMPLE 15-1	TiO <sub>2</sub>	0.25	TAYCA	JR	Al <sub>2</sub> O <sub>3</sub>	0.10	10	120	Ox-free Cu	$\geq 4.5$	$\leq 0.1$
EXAMPLE 15-2	AlN	0.80	TOKUYAMA	GRADE F	PZT	0.50	5	100	GLASS	$\geq 4.0$	$\leq 0.1$
EXAMPLE 16	TiO <sub>2</sub>	0.25	TAYCA	JR	Al <sub>2</sub> O <sub>3</sub>	0.10	50	100	Si	$\geq 5.0$	$\leq 0.1$
EXAMPLE 17	TiO <sub>2</sub>	0.25	TAYCA	JR	Al <sub>2</sub> O <sub>3</sub>	0.10	50	100	Si	$\geq 5.0$	$\leq 0.1$

FIG.24

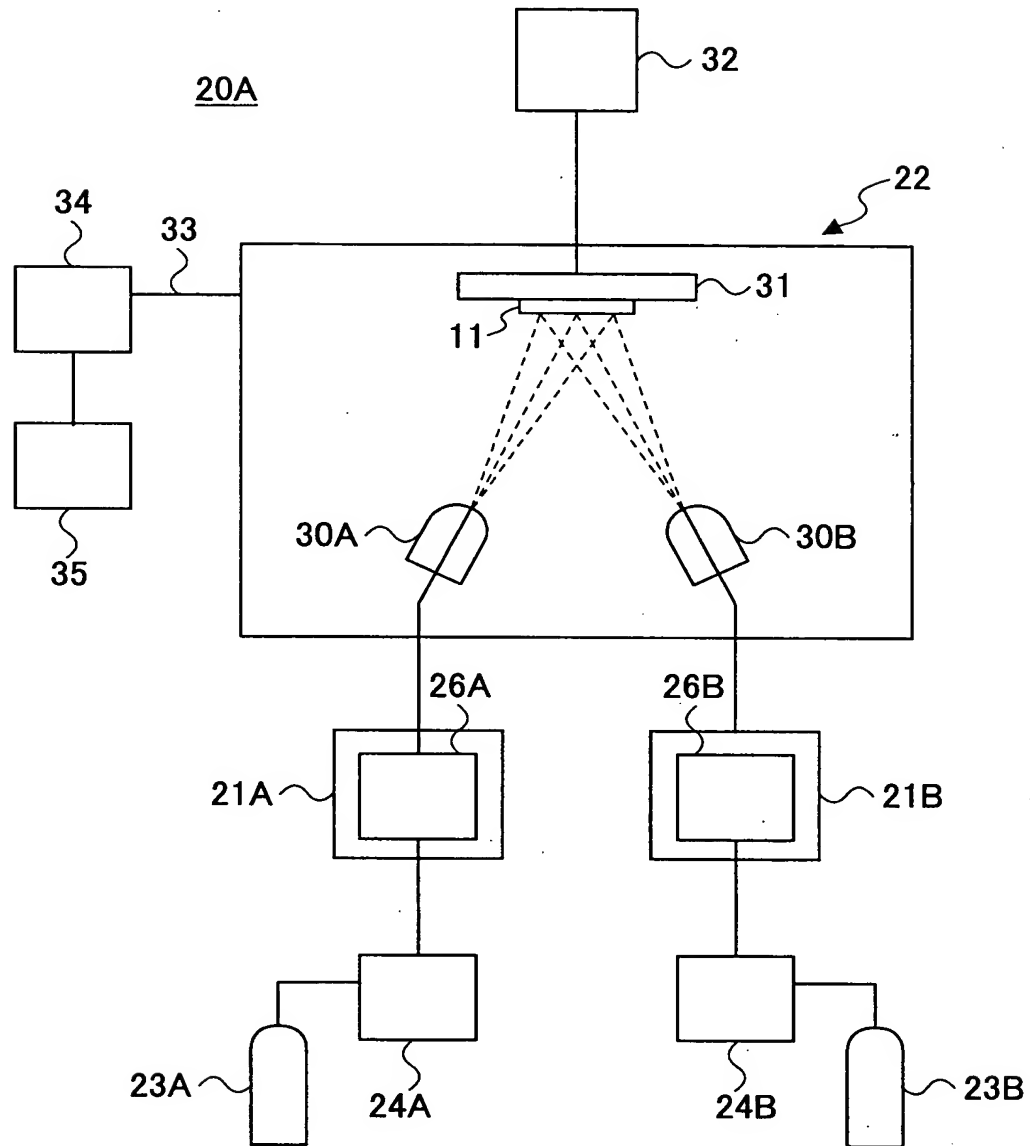
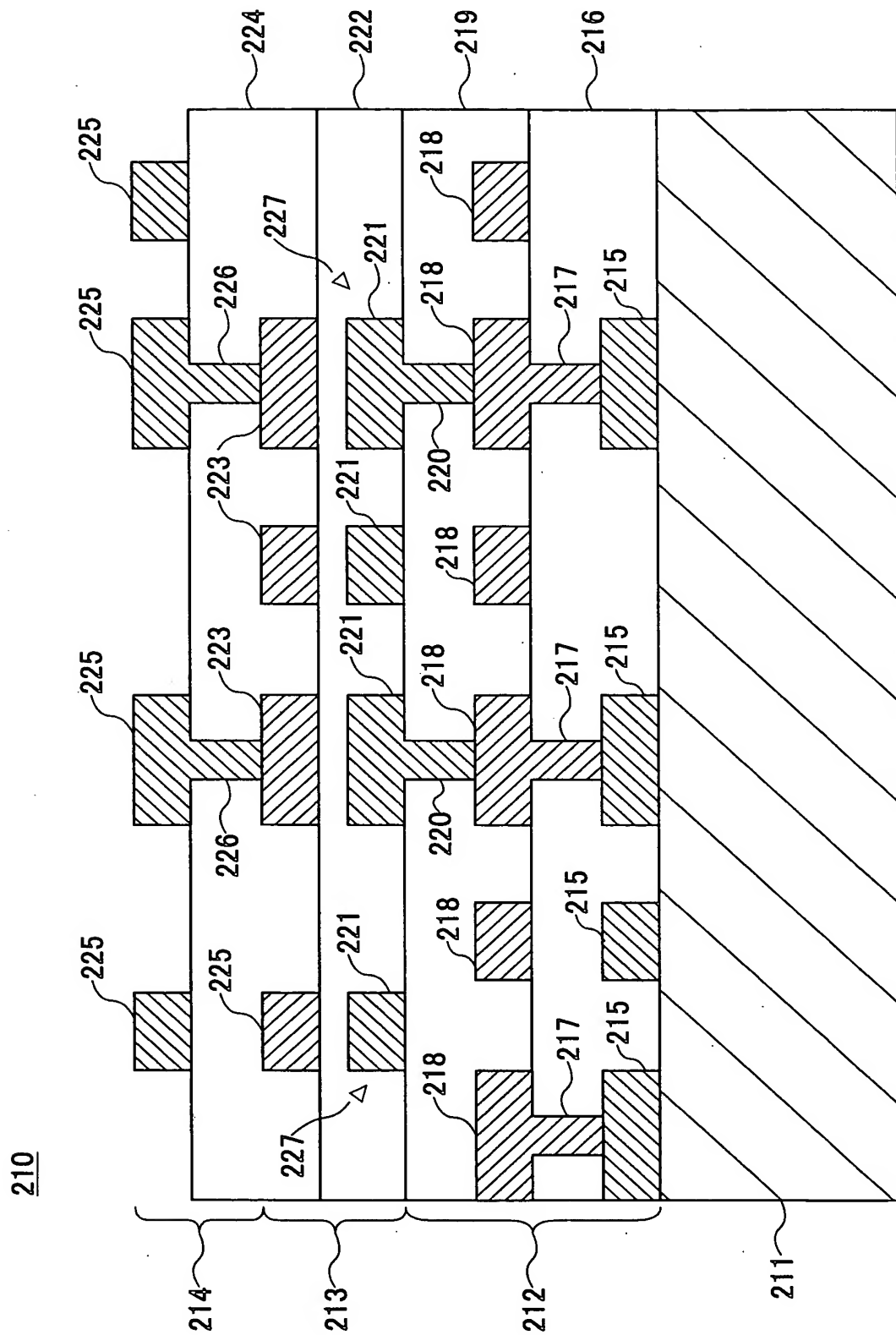
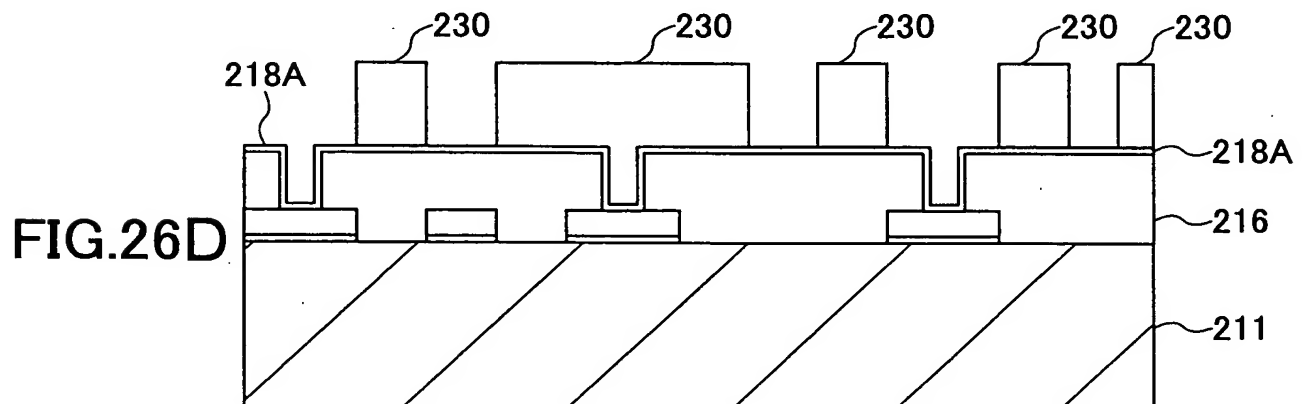
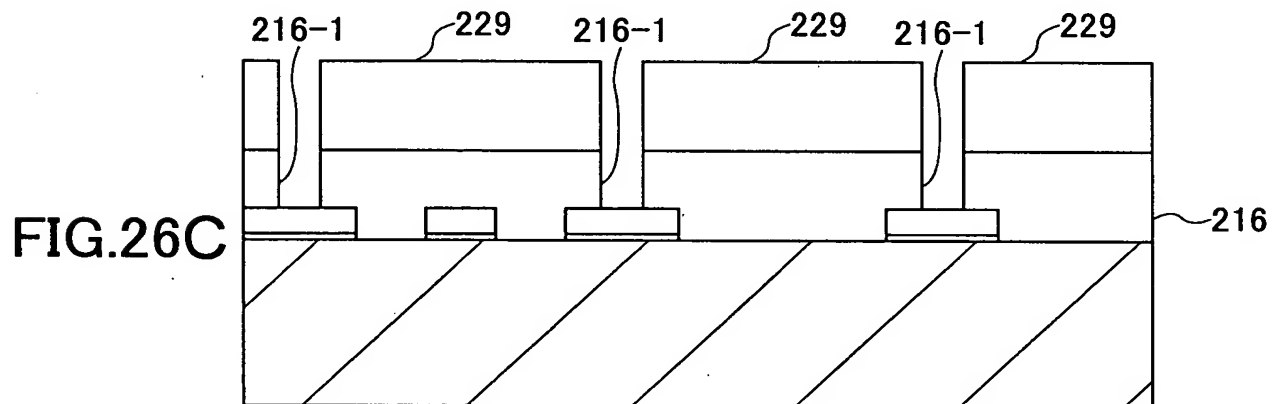
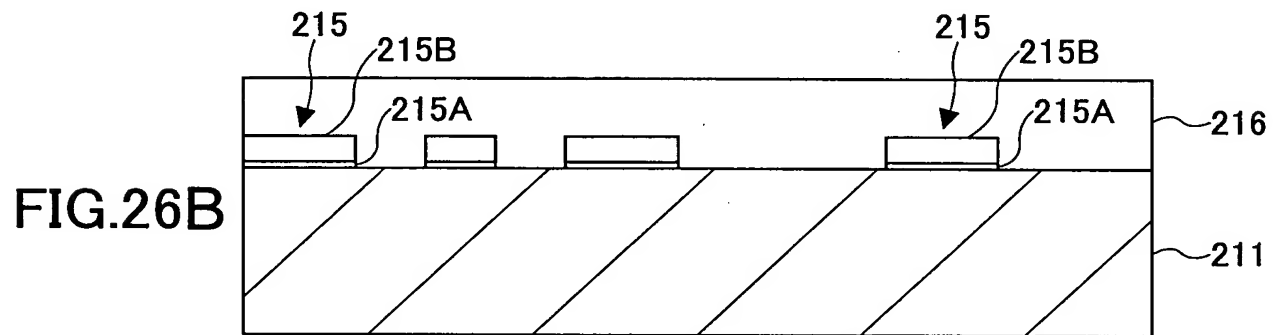
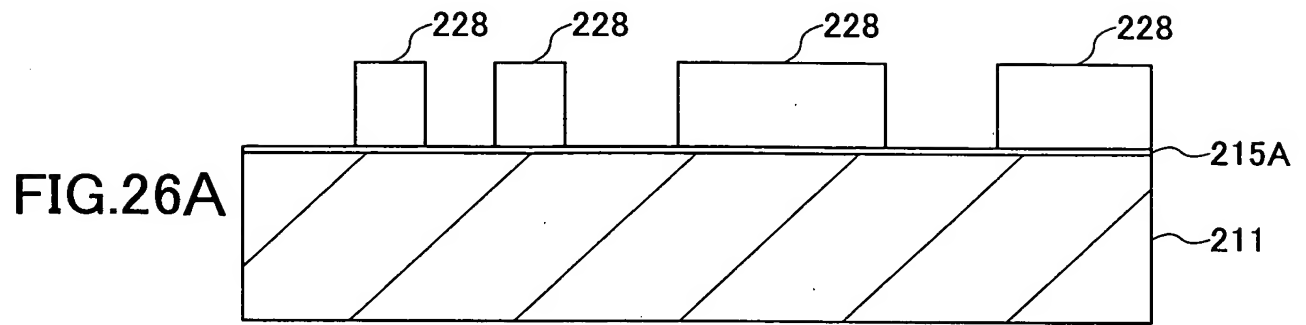
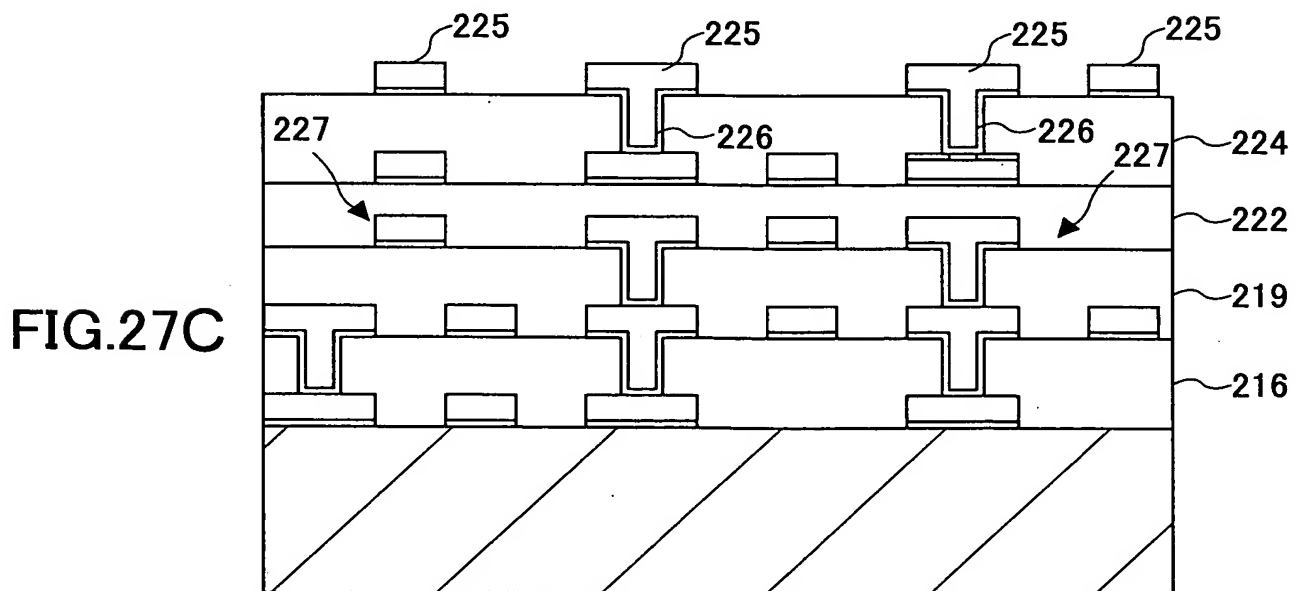
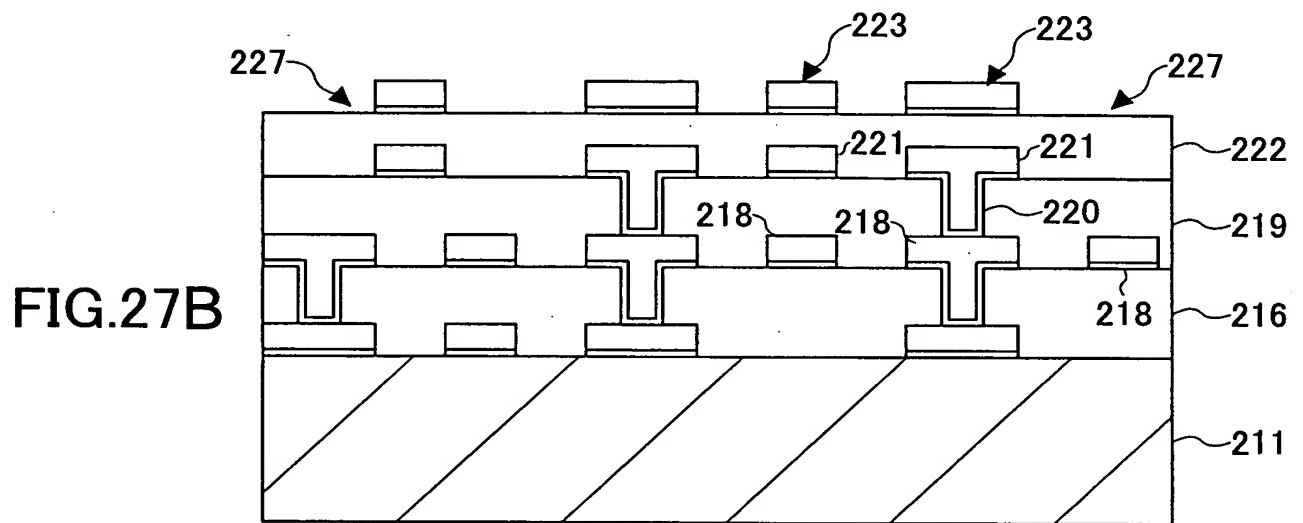
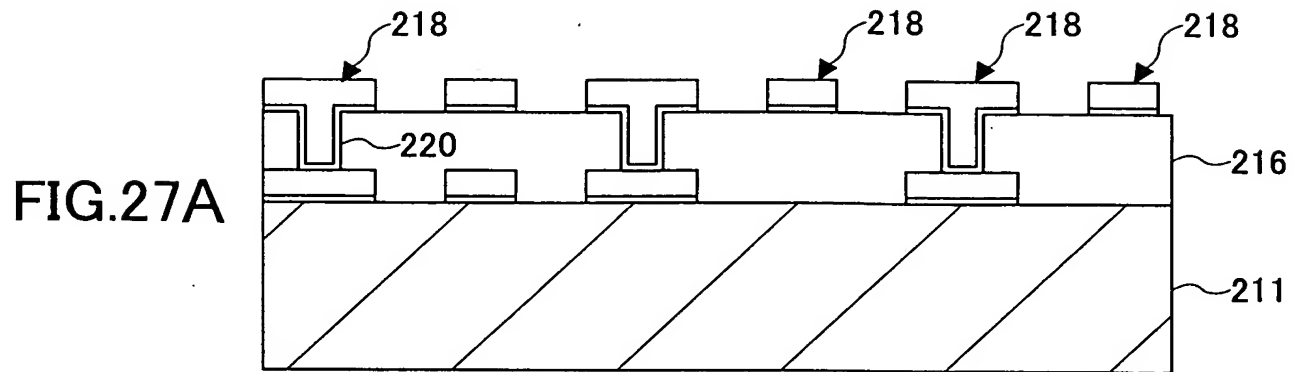


FIG. 25









**FIG. 28**

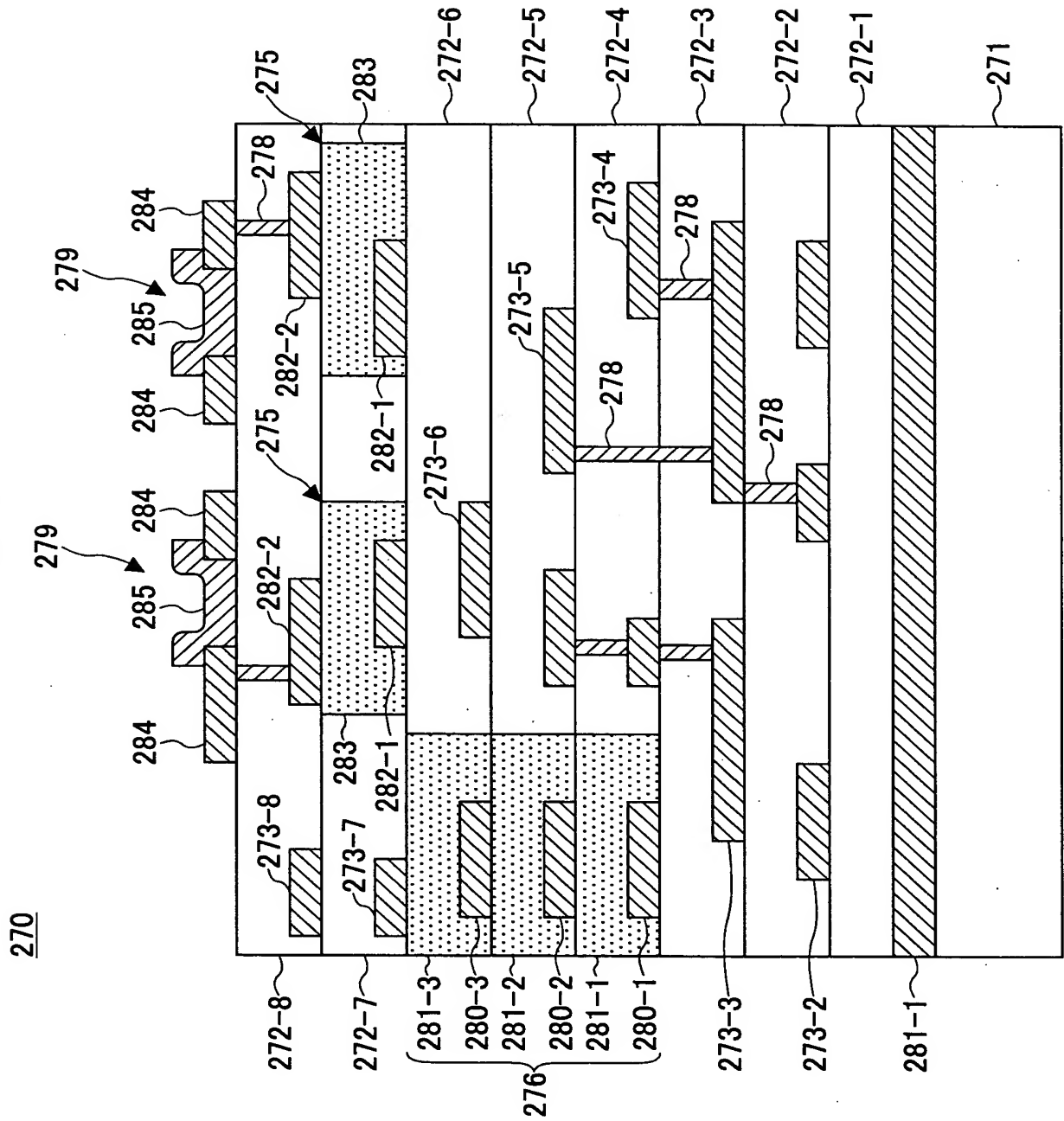


FIG.29

290

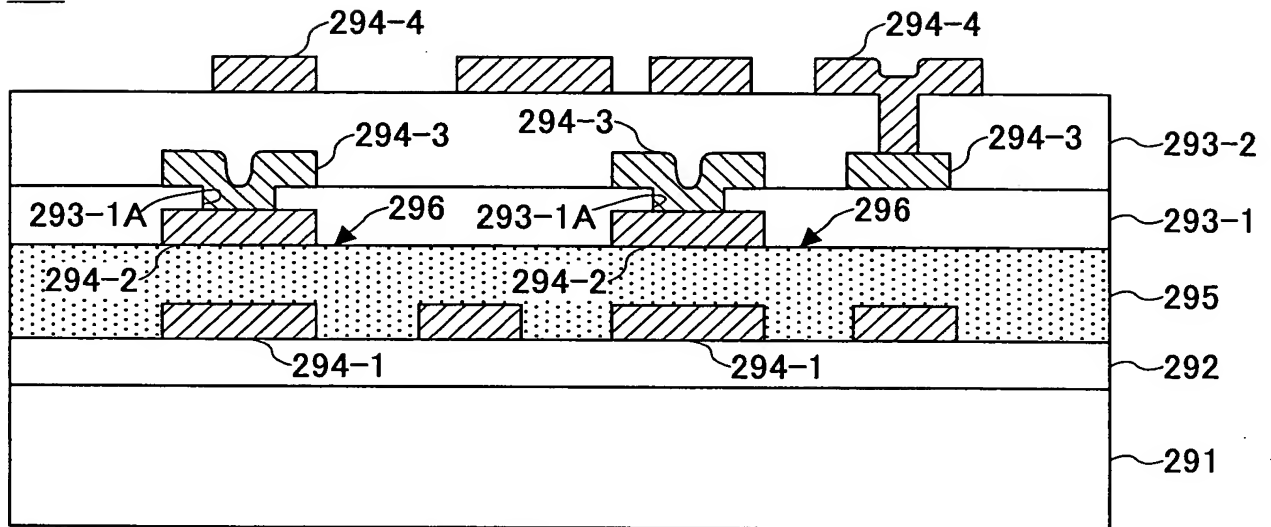


FIG.30

300

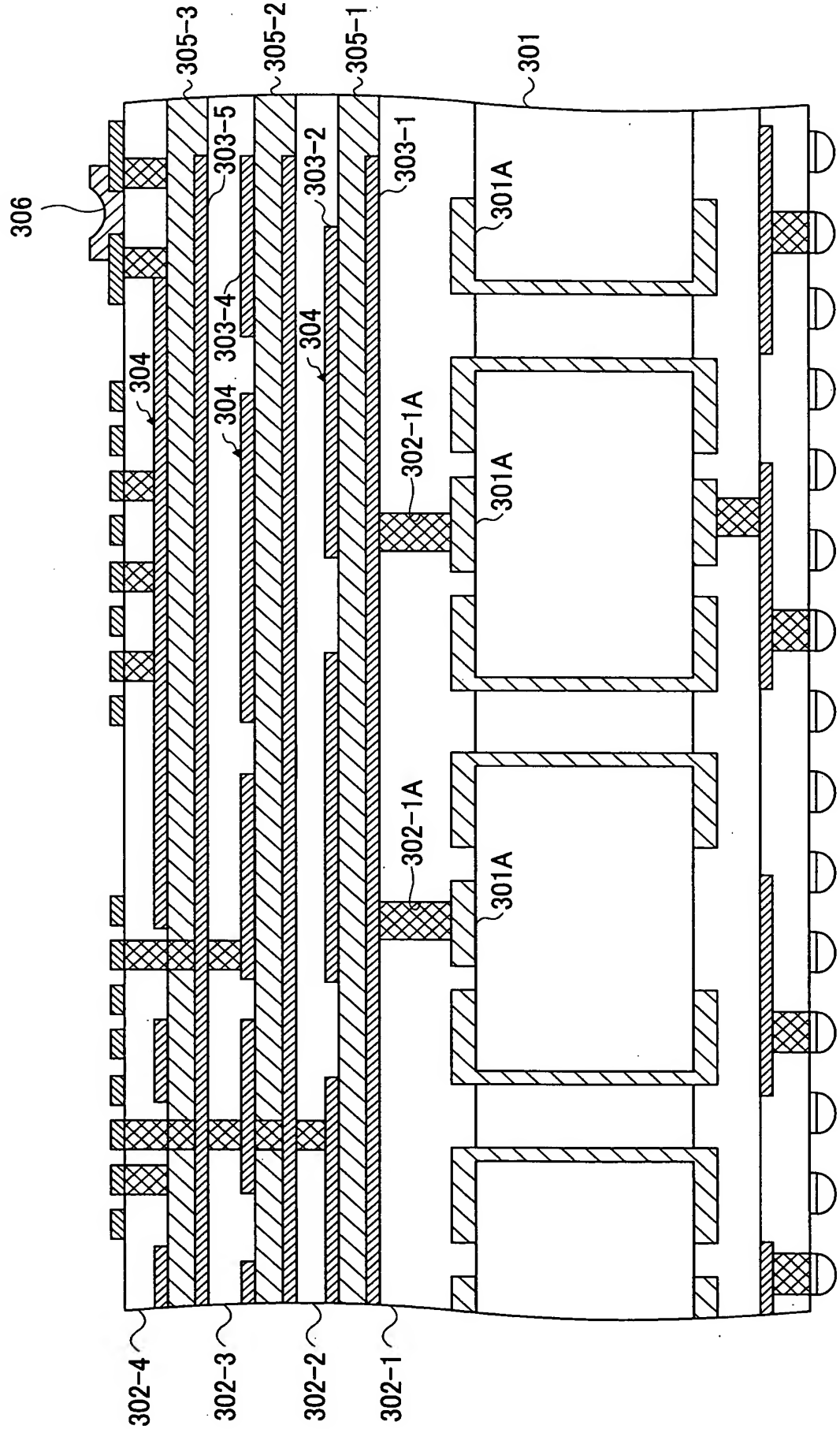


FIG.31

310

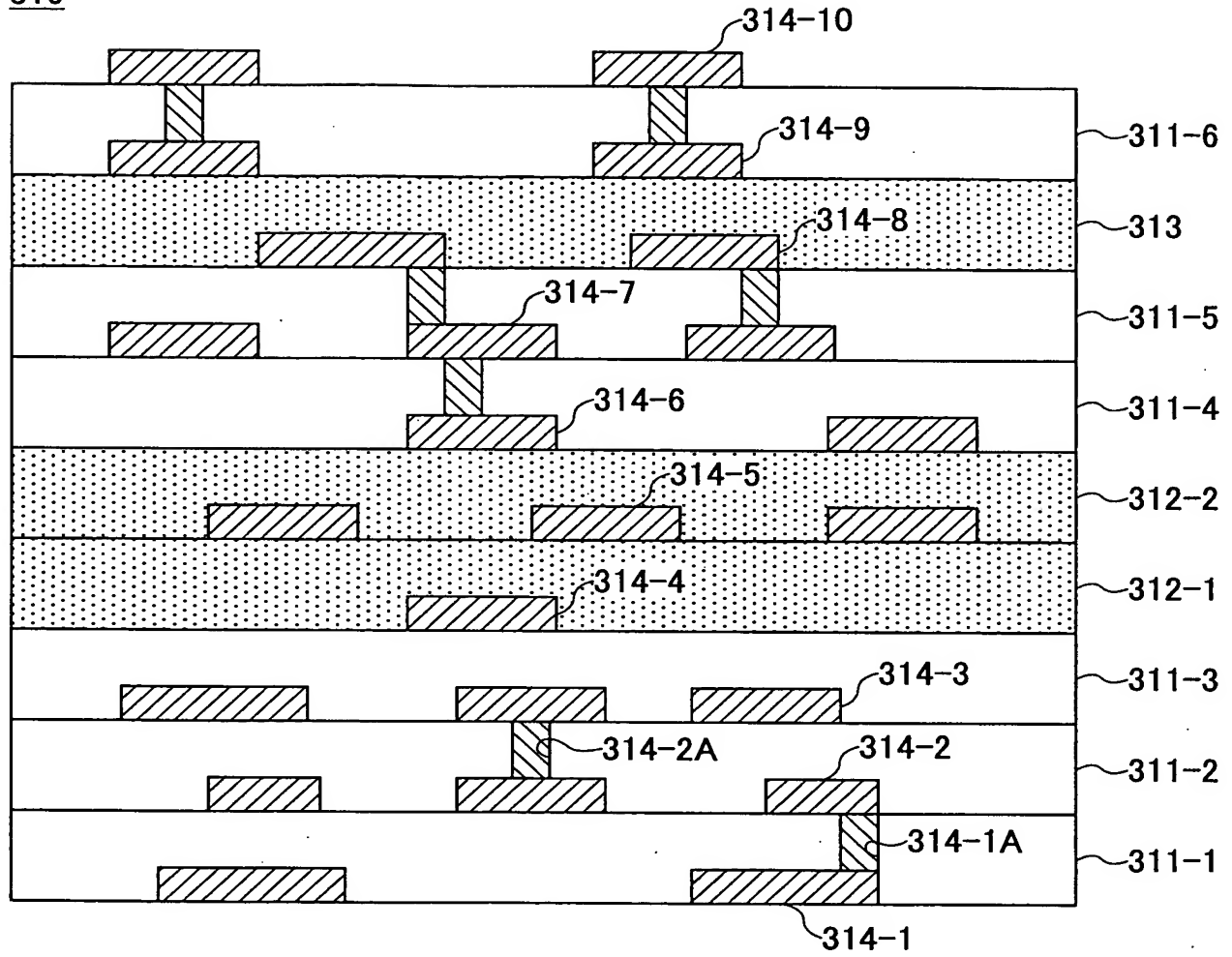


FIG.32

	INTERLAYER INSULATION FILM					CONDUCTOR LAYER		HIGH FREQ LOSS
	MATERIAL	SURFACE TREATMENT	Ave. DIAMETER ( $\mu$ m)	$\tan \delta$	MATERIAL	$\rho$ ( $\mu \Omega \cdot \text{cm}$ )	RELATIVE VALUE	
EXAMPLE 18	MgO	Al <sub>2</sub> O <sub>3</sub> COAT	0.25	0.0003	Cu PLATING	2	0.6	
EXAMPLE 19	MULLITE	Al <sub>2</sub> O <sub>3</sub> COAT	0.8	0.0004	Cu PLATING	2	0.6	
EXAMPLE 20	Ba(Mg <sub>1/3</sub> Ta <sub>2/3</sub> )TiO <sub>3</sub>	ALUMINUM ISOPROPOXIDE	0.8	0.00025	Cu PLATING	2	0.6	
EXAMPLE 21	AlN	ALUMINUM ISOPROPOXIDE	1.0	0.0005	Cu PLATING	2	0.7	
COMPARATIVE EXAMPLE 4	POLYIMIDE	—	—	0.0025	Cu PLATING	5	0.8	
COMPARATIVE EXAMPLE 5	GLASS EPOXY	—	—	0.0125	Cu PLATING	2	1	
COMPARATIVE EXAMPLE 6	GLASS · ALUMINA LTCC	—	—	0.001~0.003	CuAg THICK FILM	8	0.8	

FIG.33

	MATERIAL	SURFACE TREATMENT	Ave. DIAMETER ( $\mu$ m)	K (2GHz)	$\tan \delta$
EXAMPLE 18	Ba(Mg <sub>1/3</sub> Ta <sub>2/3</sub> )O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub> COAT	0.25	20	0.00025
EXAMPLE 19	BaTi <sub>4</sub> O <sub>9</sub>	Al <sub>2</sub> O <sub>3</sub> COAT	0.1	25	0.0003
COMPARATIVE EXAMPLE 6	Ba(Mg <sub>1/3</sub> Ta <sub>2/3</sub> )O <sub>3</sub> -GLASS COMPOSITE	—	—	15	0.00125



FIG.34

	MATERIAL	SURFACE TREATMENT	Ave. DIAMETER ( $\mu$ m)	E (2GHz)	CAPACITANCE DENSITY	RELATIVE SUBSTRATE SIZE
EXAMPLE 18	BaTiO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub> COAT	0.5	800	10	0.3
EXAMPLE 19	BaSrTiO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub> COAT	0.1	2000	20	0.3
COMPARATIVE EXAMPLE 4	BaSrTiO <sub>3</sub> -SPUTTER FILM	—	—	300	5	0.6
COMPARATIVE EXAMPLE 5	BaTiO <sub>3</sub> -EPOXY COMPOSITE FILM	—	—	50	1	1
COMPARATIVE EXAMPLE 6	CaZrO <sub>3</sub> -GLASS COMPOSIT	—	—	200	10	0.8

FIG.35

